The F.o.b.-Retail Price Relationship For Selected Fresh Vegetables

Thomas Worth[1]

Abstract: A recurring question in agriculture is to what degree are changes in grower prices reflected in retail prices. There is a perception that price increases are passed on to retail prices more quickly and completely than are price decreases. This article examines the price behavior of six vegetables: carrots, celery, lettuce, onions, potatoes, and tomatoes. The analysis indicates that for celery, lettuce, onions, and potatoes there is no evidence of price asymmetry. For carrots and tomatoes, however, there is evidence that retail prices show a greater response to f.o.b. price increases.

Keywords: vegetables, prices, retail, f.o.b., asymmetry, tomatoes, carrots, lettuce, potatoes.

A recurring question in agriculture is to what degree are changes in grower prices reflected in changes in retail prices. Recent mergers in the retail industry renew concerns that retailers have gained an ability to increase their margins at growers' expense. Retailers may increase their margins by keeping grower prices lower than they would be if retail competition were greater. Alternatively, retailers can increase margins by raising retail prices, which would decrease demand for growers' output. In either case, an increase in the retailer margin has a negative effect on growers.

Retailers must account for a variety of costs when determining their prices. The largest among them are labor, packaging, and transportation. In the case of produce, the costs are higher than for most other food products and are reflected in the grower-retail price margin. In 1996, the fresh produce margin was 44 percent compared with an average of 30 percent for all foods (Elitzak, 1999, p.10). The greater cost is partly due to the perishability, shrinkage, and the additional labor fresh fruits and vegetables entail. Refrigeration during transportation also contributes to the cost of selling fresh produce.

A portion of the retail price also reflects profit. Fresh produce contributes disproportionately to store-wide profits. They account for 8.7 percent of total supermarket sales but supply about 20 percent of net profit (Elitzak, 1999, p.10). The overall profitability of retail food chains is similar to that of other industries that produce nondurable goods. In 1997, the return on stockholder equity for retail food chains was 17.4 percent. This is only slightly above the 17.0 percent average return on equity for all non-durable goods industries (Elitzak, 1999, p.19).

Free-on-board shipping-point prices (f.o.b.) may not be fully transmitted to retail prices because of several factors. First of all, retailers generally attempt to maintain constant prices so as not to lose goodwill with their customers. If a retailer believes that a decrease in f.o.b. prices is temporary, he or she may choose to keep prices constant. For commodities that are less perishable, changes in existing stocks may reduce the effect of supply shocks, such as bad weather, on f.o.b. prices and on retail prices. Finally, any change in a retailer's expenses will cause a change in the f.o.b.-retail margin.

This article examines the price behavior of six vegetables: carrots, celery, lettuce, onions, potatoes, and tomatoes. The variability of f.o.b. and retail prices is first examined. With a couple of exceptions, the retail price and f.o.b. price variability has declined for all of the selected commodities. The following section examines the retail and f.o.b. price trends over time. Prices rise steadily over time for most of the commodities, except for carrots and tomatoes where it appears that retail price increases accelerated in the 1990's. In the last section, a statistical test finds evidence that retail prices for carrots and tomatoes respond more to f.o.b. price increases than to f.o.b. price decreases.

F.o.b. and Retail Price Variance

One way to compare f.o.b. prices with retail prices is by the amount of variance they exhibit. If f.o.b. prices are passed through immediately and completely to retail prices, they should vary together and exhibit the same variance. If

[1] Agricultural economist, Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture.

retailers do not adjust their prices completely in response to f.o.b. price changes, retail prices should have a smaller variance. Reasons for retail prices to have a smaller variance include the cost of changing a retail price, such as the labor involved in repricing fresh produce. The retailer may also lose some goodwill from consumers who prefer stable prices.

The means, standard deviations, and coefficients of variation for retail prices, f.o.b. prices, and the resulting margins for the selected vegetables are listed in table B-1. The coefficients of variation are the ratio of the standard deviation to the mean. This statistic provides a convenient way to compare the price variance of different commodities in a way that corrects for the fact that each commodity has a different mean. The data are split in half around 1980. The first number in each cell covers 1960-1979 and the second number covers 1980 to May 1999 (except for onions where the data ends in December 1997). All of the data share a common gap of July 1978 to December 1979 when data were not collected. The f.o.b. price data are supplied from the National Agricultural Statistics Service (NASS) at the U.S. Department of Agriculture, and the retail price data are supplied by the Bureau of Labor Statistics at the U.S. Department of Labor. The data, which consist of nearly 40 years of monthly observations, are split in two parts to test if agricultural markets have changed.

Table B-1 indicates that retail prices vary less than f.o.b. prices. This applies to all of the commodities and for both time periods. This suggests that retailers do not adjust their prices fully to the f.o.b. price changes they encounter on the market. Except for carrots and potatoes, the variance of the retail-f.o.b. margin is closer to the retail price variance than to the f.o.b. price variance. Although retailers are keeping their prices more constant than f.o.b. prices, they are adjusting prices enough to reduce the variance in their margins. This pattern of variability is consistent with both asymmetric price adjustment and with markup pricing (Pick et al., 1990).

For all commodities, the variance of the retail prices and the retail-f.o.b. margins drop from the first time period to the second. In 4 of the 6 cases, this mirrors a drop in the variance of f.o.b. prices. A more stable supply of fresh produce, likely due to improvements in agricultural techniques and increased imports, contributes to a reduction in the variance in grower prices.

There are, however, two notable exceptions. The variance of f.o.b. prices for tomatoes and lettuce increase in the second time period, albeit only slightly. In the case of lettuce, the increased variance is due to large price increases at the end of 1987 and again from December 1994 to September 1995. A possible explanation for the increased variability of lettuce f.o.b. prices is the growing proportion of the market accounted for by direct contracts between seller and grower. This reduces the size of the residual spot market, which, in turn, tends to increase the variability of prices. Another explanation may be that the increased use of contracts may

Table B-1--Variance of retail and f.o.b. prices over time

Commodity	Time series	Price series 1/	Mean 1960-79/1980-99	Standard deviation 1960-79/1980-99	Coefficient of variation 1960-79/1980-99
Carrots	Jan. 1960 to May 1999, except July 1978 to Dec.1979	Retail	0.197 / 0.423	0.055 / 0.075	0.279 / 0.177
		F.o.b.	0.068 / 0.131	0.026 / 0.029	0.382 / 0.221
		Margin	0.133 / 0.292	0.035 / 0.065	0.263 / 0.223
Celery	Jan. 1960 to May 1999, except July 1978 to Dec. 1979	Retail	0.205 / 0.505	0.070 / 0.098	0.341 / 0.194
		F.o.b.	0.061 / 0.125	0.028 / 0.043	0.460 / 0.344
		Margin	0.147 / 0.381	0.050 / 0.074	0.340 / 0.194
Lettuce	Jan. 1960 to May 1999 except July 1978 to Dec.1979 and Jan. 1987 to Feb. 1987	Retail	0.179 / 0.602	0.070 / 0.152	0.391 / 0.252
		F.o.b.	0.060 / 0.135	0.029 / 0.067	0.483 / 0.496
		Margin	0.121 / 0.467	0.052 / 0.108	0.430 / 0.231
Onions	Jan. 1960 to Dec. 1997, except July 1978 to Dec. 1979	Retail	0.165 / 0.389	0.065 / 0.083	0.394 / 0.213
		F.o.b.	0.059 / 0.129	0.033 / 0.047	0.559 / 0.364
		Margin	0.107 / 0.260	0.045 / 0.063	0.421 / 0.242
Potatoes	Jan. 1960 to May 1999, except July 1978 to Dec. 1979 and Jan. 1987 to Feb. 1987	Retail	0.098 / 0.299	0.037 / 0.074	0.378 / 0.248
		F.o.b.	0.029 / 0.057	0.013 / 0.015	0.448 / 0.263
		Margin	0.070 / 0.242	0.026 / 0.067	0.371 / 0.277
Tomatoes	Jan. 1960 to May 1999, except July 1978 to Dec. 1979 and Jan. 1987 to Feb. 1987	Retail	0.432 / 0.982	0.135 / 0.310	0.313 / 0.316
		F.o.b.	0.139 / 0.301	0.059 / 0.136	0.424 / 0.451
		Margin	0.298 / 0.681	0.092 / 0.243	0.309 / 0.357

1/ Prices are expressed in U.S. dollars per pound.

leave a residual demand for spot market output that is less elastic. A decrease in the elasticity of demand can increase the variability of prices. For tomatoes, the increased price variability is due to price spikes early in 1990, 1992, and 1996. Although the variance of f.o.b. prices for tomatoes and lettuce increased, the variance of retail prices and the margin still decreased.

F.o.b. and Retail Price Trends

The f.o.b. and retail price trends are rising for all of the selected commodities. Prices for the second time period, 1980-99, are presented in figure B-1. The solid lines in the graphs represent a two-year moving average for retail and for f.o.b. prices. Retail prices consistently rise during this time period. Except for potatoes, f.o.b. prices rise consistently, albeit modestly, as well. The retail-f.o.b. margin increases for all of the commodities.

Although all retail prices rose throughout the time period, they do not all rise at the same rate. Carrots and tomatoes rose more rapidly during the 1990's than lettuce, onions, and celery. The retail price of potatoes increased steeply from 1989 to 1990 and then retreated. This is due to an increase in processor demand as described in an earlier article (Love, 1993).

The transmission of f.o.b. prices to retail prices is evident in the dramatic price increases in celery in the mid-1990's or in lettuce in 1989 and 1995. Although it appears that prices move together, what is harder to discern from figure 1 is the extent to which f.o.b. price changes are reflected in retail prices. When f.o.b. prices rise, is the increase fully reflected in the retail price? When f.o.b. prices fall, does the decrease get fully passed on to retail prices? Is there a bias in retail prices in that they fully reflect f.o.b. price increases but not the decreases?

Another way of phrasing these questions is whether retail prices respond symmetrically to both f.o.b. price increases and decreases. This is addressed in the next section.

An Analysis of F.o.b.-Retail Price Changes

Several studies have examined vertical price transmission in fresh produce. The first question that they address is whether f.o.b. price changes precede retail price changes or vice-versa. One possibility is that fresh produce prices are driven more by shifts in demand than by changes in supply. The chain of events in this situation is that increased demand causes retail prices to rise which, in turn, leads to increases in f.o.b. prices. This would be a long-run phenomenon. In the short-run, prices are affected more by supply. An increase (decrease) in supply causes f.o.b. prices to fall (rise) which, in turn, leads to decreases (increases) in retail prices. All of the studies indicate that short-run f.o.b. price changes precede retail price changes (Ward, 1982; Powers, 1995; Heien, 1980). In other words, f.o.b. prices affect retail prices and not the other way around.

In examining the transmission of f.o.b. prices to retail prices, studies reach different conclusions. Studies that look at market prices in specific cities find that the adjustment of retail prices to f.o.b. price changes generally occurs within a month (Ward, 1982; Pick et al., 1990; Powers, 1995). When using national-level data, the adjustment time appears to be much longer – from 1 to 4 months (Heien, 1980). This might indicate that all of the markets in the United States, when taken as a whole, react slowly even though some individual markets may react more quickly.

The conclusions about whether retail prices respond symmetrically to f.o.b. (or wholesale) price changes varies between studies as well. One study reports some evidence that retail prices respond more to wholesale price decreases than increases (Ward, 1982). Other studies, examining the markets in specific cities, find evidence of the opposite (Pick et al., 1990; Powers, 1995).

For this analysis, national data are used to test whether price asymmetries found in specific markets hold for the United States in general. For comparability, the estimation technique used here is similar to that used in previous studies (Ward 1982; Pick et al., 1990; Powers, 1995). The data used are monthly f.o.b. and retail prices from January 1980 to May 1999 (except for onions where the data end on December 1997). Earlier data, though available, are not used because of changes in agricultural markets since 1960.

The estimation equation separately measures the effect of f.o.b. price increases (*FOBUPSUM*) and f.o.b. price decreases (*FOBDOWNSUM*) on the retail price (*RETSUM*). The equation is:

$$RETSUM_t = a_1 FOBUPSUM_t + a_2 FOBDOWNSUM_t + a_3 TREND_t + e_t \quad (1)$$

where:

$$RETSUM_t = RET_t - RET_0$$

$$FOBUPSUM_t = \sum_{i=1}^{t} (FOBUP_i)$$

$$FOBDOWNSUM_t = \sum_{i=1}^{t} (FOBDOWN_i)$$

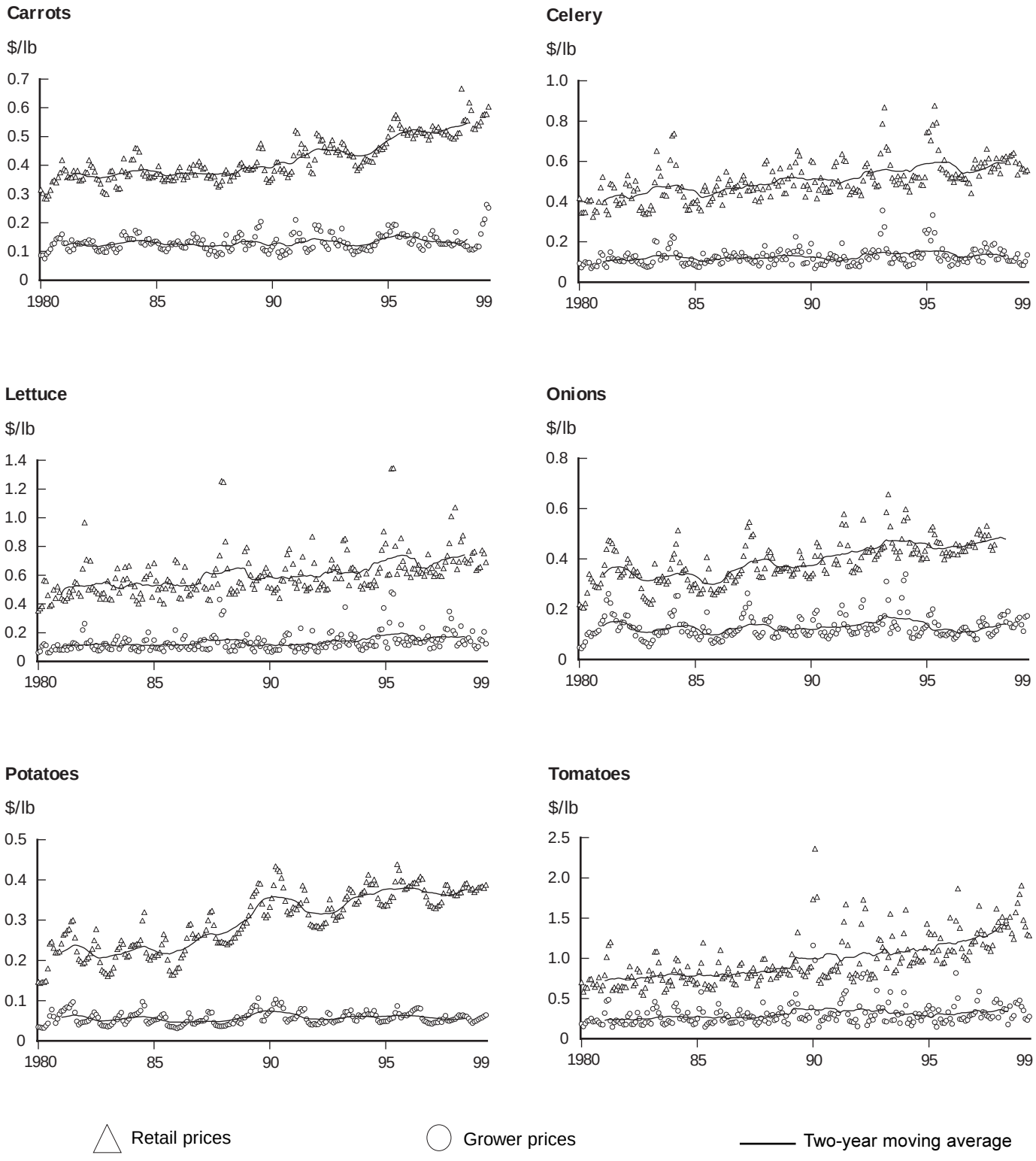
and:

$$FOBUP_i = \begin{cases} FOB_i - FOB_{i-1} & \text{if } FOB_i > FOB_{i-1} \\ 0 & \text{otherwise} \end{cases}$$

$$FOBDOWN_i = \begin{cases} FOB_i - FOB_{i-1} & \text{if } FOB_i < FOB_{i-1} \\ 0 & \text{otherwise} \end{cases}$$

Figure B-1

Monthly f.o.b. and retail prices for selected vegetables, January 1980 to May 1999



Source: Economic Research Service, USDA.

The variable $RETSUM_t$ is the change in the retail price from its initial value (RET_0) to its value at time t (RET_t). For this estimation, the initial value is the price as of January 1980 – the first observation of the dataset. The sum of all of the f.o.b. price increases as of time t ($FOBUP_i$) is $FOBUPSUM_t$. Similarly the sum of all of the f.o.b. price decreases as to time t ($FOBDOWN_i$) is $FOBDOWNSUM_t$. The two variables $FOBUPSUM_t$ and $FOBDOWNSUM_t$ separate out the effects of price increases and price decreases on the retail price. The sum of the two variables equals the overall change in the f.o.b. price from time *0*. The time trend variable is $TREND_t$.

As discussed in the introduction, there are several factors that affect the f.o.b.-retail margin, such as transportation and labor costs. The inclusion of the trend variable accounts for these costs. This implicitly assumes that the costs that are contributing to the margin are changing at a constant rate.

If retail prices respond equally to f.o.b. price increases and decreases, then $a_1 = a_2$ in equation 1. If retail prices respond more to f.o.b. price increases than to f.o.b. price decreases, then $a_1 > a_2$. The opposite holds if retail prices respond more to f.o.b. price decreases.

As indicated by earlier studies, there is a lag between f.o.b. price changes and retail price changes. The lags for each commodity in this study are determined by estimating equation 1 with values of *FOBUPSUM* and *FOBDOWNSUM* lagged up to 4 months (Pick et al., 1990). The lags that are different from zero with a confidence level of 20 percent are retained. To test for asymmetry, the coefficients for all of the lags of *FOBUPSUM* and *FOBDOWNSUM* are summed up and then compared. If there are *m* lags of *FOBUPSUM* and *n* lags of *FOBDOWNSUM* then the test is:

$$\sum_{j=0}^{m} a_{1j} = \sum_{j=0}^{m} a_{2k} \qquad (2)$$

A Durbin-Watson test indicated the presence of autocorrelation in the data. As a result the estimation is done using a linear regression with the Prais-Winston procedure to correct for autocorrelation. The results are listed in table B-2. The table also includes a test of equation 2 and the lags used for each commodity.

The number of monthly lags varies across the commodities. The lag for lettuce and carrots is greater for price increases than for price decreases. For the rest of the commodities, there is a greater lag for f.o.b. price decreases. Although this gives some indication of the speed of adjustment, it is not definitive. For example, the lag for f.o.b. price increases in carrots is 3 months. This simply indicates that the lagged coefficients are statistically significant, but does not indicate whether the coefficients are economically significant. It may be that most of the change in the retail price occurs in the first month. The remaining months, while statistically significant in terms of t-statistics may account for a small remainder of the retail price change.

The coefficients for the f.o.b. price increases (Σa_1) are higher than the coefficients for f.o.b. price decreases (Σa_2) for carrots, onions, and tomatoes. They are nearly equal for celery and lettuce. The coefficient for the f.o.b. price decrease is greater than for the increase for potatoes.

Table B-2--Symmetry tests of retail price response to f.o.b. price changes for selected vegetables

Commodity	Number of lags included (months)		Price coefficients (standard errors)			t-value for the test $\Sigma a_1 = \Sigma a_2$	R-squared
	Price increase	Price decrease	Σa_1	Σa_2	a_3		
Carrots	3	1	1.248[c] (0.138)	1.084[c] (0.128)	-0.0004 (0.0004)	8.16	0.82
Celery	1	2	2.007[c] (0.098)	2.027[c] (0.093)	0.0009[c] (0.0004)	0.42	0.89
Lettuce	2	1	2.296[c] (0.157)	2.306[c] (0.155)	0.0001 (0.0005)	0.18	0.77
Onions	1	3	1.393[c] (0.111)	1.361[c] (0.122)	-0.0008 (0.0017)	0.04	0.60
Potatoes	1	3	2.341[c] (0.279)	2.555[c] (0.222)	0.0008 (0.0011)	0.39	0.69
Tomatoes	1	2	1.857[c] (0.086)	1.752[c] (0.082)	-0.0037[c] (0.0013)	10.53	0.79

[c] = Significant at the 1 percent level.

Although the gap is larger than for any of the other commodities, it is not statistically significant. Of the six commodities examined, only carrots and tomatoes show a difference that is statistically significant. In other words, these are the only commodities that show evidence of price asymmetry. In both cases retail prices respond more to f.o.b. price increases than to f.o.b. price decreases.

Conclusion

For celery, lettuce, onions, and potatoes there is no evidence of price asymmetry. In the case of carrots and tomatoes, however, statistical results show that retail prices show a greater response to f.o.b. price increases. These results would lead to concern that retailers have gained enough market power with carrots and tomatoes to increase the f.o.b.-retail margin at growers' expense. Finding that a price asymmetry exists is not enough to reach this conclusion. There are many factors that affect the f.o.b.-retail margin. The price asymmetry may be due to increasing expenses on the retailer's part, such as labor or transportation, rather than to an increase in profits. Precise data on retail expenses, which is not generally available, would be needed to explore the cause of the price asymmetry and why it is evident only for carrots and tomatoes.

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